

Agricultural Research **Service**



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Research from the Soil Resource **Management and Water Quality National Programs**

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1PC Research Note

Broiler Litter: Waste or Resource?

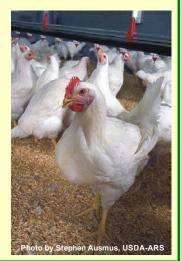
Why does it matter?

Since the turn of the 21st century, Georgia has ranked 1st in the country in the number of broiler chickens, with about 1.4 billion sold each year. In the 2007 Census of Agriculture, Madison County farmers sold 48.2 million broilers, ranking 8th in the state behind leader Franklin County, which sold 104.1 million broilers. One out of every 4 broilers sold in Georgia (26%) are produced in the 8 county region surrounding Madison County (Banks, Clarke, Elbert, Franklin, Hart, Jackson, and Oglethorpe

Counties). It is easy to see that broiler production in the region is a

major agricultural enterprise.

Along with the great number of broilers produced and sold in the region, a large volume of manure must be handled. Assuming an average of 5 lbs of manure produced during the lifetime of each bird, there's a lot of "stuff" left behind from these production facilities. In fact, if one were to stack a year's worth of manure from the 8-county area into the University of Georgia's Sanford Stadium, we'd find that the stadium would be filled and even overflowing! Fortunately, area producers have found ways to get rid of the stuff and Nature has a way of turning the unpleasant characteristics into high quality food for the soil. Often called "animal waste", this byproduct of broiler production is highly valued as a fertilizer for nearby pastures and cropland. This animal waste is, therefore, really a valuable resource for farmers, especially considering the cost of commercial fertilizer during recent years.



What was done?

At the Watkinsville Research Center (USDA - Agricultural Research Service), several field experiments have been and are currently being conducted in collaboration with scientists at the University of Georgia to study how broiler litter can be effectively utilized as an organic fertilizer to increase crop and pasture productivity, while at the same time, protect the environment from pollution.

What was found?

Broiler Litter on Coastal Bermudagrass

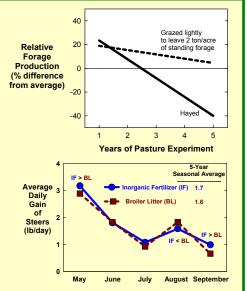
The impact of broiler litter fertilizer on pasture productivity, steer weight gain, and a variety of soil properties was assessed on a 30-acre site from 1994 to 1998 near Farmington GA. Broiler litter (Fertilizer A) was compared with inorganic fertilizer (Fertilizer B) and crimson clover cover crop + inorganic fertilizer (Fertilizer C) in replicated Coastal bermudagrass pastures that were harvested in one of four different approaches: unharvested as conservation reserve grassland (Harvest 1), hayed regularly (Harvest 2), grazed by yearling steers to leave standing forage of 1 ton/acre (Harvest 3), and grazed by yearling steers to leave standing forage of 2 ton/acre (Harvest 4). During the first 5 years, broiler litter was applied twice per year at a rate of 1% ton/acre each time in May and in July. This rate supplied pastures with an average of 175 lb of N (nitrogen), 250 lb of P₂O₅ (phosphate), and 175 lb of K₂O (potash) per acre each year. The inorganic fertilizer treatment was supplied with 200 lb of N and 35 lb of P₂O₅ per acre each year. The target of 200 lb N/acre/year was determined as a balanced amount to achieve high productivity, while minimizing potential nitrogen loss to the environment.

Bermudagrass hay production varied from 2 to 4.5 ton/acre, depending upon precipitation received. Hay production with broiler litter application averaged 3.1 ton/acre. With inorganic fertilizer, hay production was 3.7 ton/acre. For producers with their own poultry houses and access to broiler

Broiler Litter on Coastal Bermudagrass (continued)

manure, a significant economic savings can be expected these days even with the slightly lower hay yield. Given the unexpected slightly lower nitrogen input with broiler litter in this study, bermudagrass hay production should not be considered different between broiler litter and inorganic fertilizer.

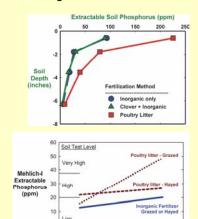
Bermudagrass forage production changed with time in this experiment. When hayed or left unharvested, relative forage production declined with time similar to the general decline in rainfall during this study. However when grazed by steers, forage production remained stable through time, as seen in the figure at top-right. It appears that pastures grazed by cattle were able to withstand variations in weather and may have benefited from the return of nutrients in fecal droppings directly onto pastures. Botanical composition of pastures was not affected whether supplied with broiler litter or inorganic fertilizer. The only major change in pasture composition was a slow decline in Coastal bermudagrass with time when grazed heavily or hayed. The more intense grazing pressure resulted in encroachment with the less-productive common bermudagrass, winter annual broadleaf weeds, and bare ground. Whether fertilized with inorganic or broiler litter, pastures should be managed with an appropriate stocking density to allow vigorous regrowth of preferred forage species.



Steer performance over the summer was the same when bermudagrass pastures were fertilized with broiler litter or inorganic fertilizer. Steer gain from May to September averaged 1.6 lb/day. The figure above-right illustrates the general effect of declining bermudagrass forage quality towards the end of summer, irrespective of whether forage was supplied with broiler litter or inorganic fertilizer.

Two important environmental implications from this study were obtained, one negative and one positive. Since broiler litter was applied to pastures to supply sufficient nitrogen, an excess amount of phosphorus occurred. After 5 years of broiler litter application, phosphorus concentration increased nearest the point of application (the soil surface), but was similarly low below 6 inches of soil depth (see figure at right). Many soils in Georgia are deficient in phosphorus, so the application of broiler litter can be very beneficial for pasture and crop production. However with very high phosphorus levels in pastures fertilized repeatedly with broiler litter, water that runs off pastures can carry with it a significant amount of soluble phosphorus that can lead to algae blooms in rivers, ponds, and lakes. Such algae blooms can deplete oxygen in water and lead to fish kills. Soil testing and nutrient management plans are needed to avoid this potential negative consequence of broiler litter application.

A positive environmental benefit from broiler litter application to pastures is the accumulation of carbon (C) in surface soil organic matter. Carbon accumulation in soil (or soil C sequestration) is a benefit to (a) land owners because it builds the natural fertility of soil and (b) society because it removes carbon dioxide from the atmosphere and can help to slow global warming. In this experiment, nitrogen applied as fertilizer fed the plants, but ¾ of the nitrogen that was applied ended up being sequestered in the build-up of soil organic matter. This means that the soil under



pastures became enriched in nutrients with a slow release as organic matter decomposed. An analogy can be made with an investment placed in the bank and yearly return of interest accruing on this investment. In research at Watkinsville, the amount of carbon sequestered in soil from broiler litter can be expected to be about 8% of the carbon applied as broiler litter. Therefore, with the application of 3 ton/acre of broiler litter each year, soil organic C can be expected to increase by 130 lb/acre/year. This amount is in addition to the 400 to 1000 lb/acre/year increase in soil organic C that can be expected with different pasture management approaches. Landowners have the opportunity to sell validated C credits through the Chicago Climate Exchange at market prices that have varied from \$0.30 to \$0.70 per hundred pounds of C. Talk to your local extension agent or contact the Georgia Forestry Commission, who sponsors the Georgia Carbon Sequestration Registry (www.gacarbon.org), to get details on how you could participate in this C credit program.

Transport of Hormones in Land-Applied Broiler Litter

Hormones from human and livestock waste have occasionally been found in ponds, lakes, and rivers in various parts of the world. These hormones have the potential to adversely affect aquatic life and create a risk to human health. The hormones estradiol and testosterone are found in broiler litter. Whether they appear in water runoff, streams, and groundwater is being investigated in field studies at the Watkinsville Research Center. In controlled conditions in the laboratory, hormone movement through the soil could be detected in soil cracks and earthworm channels. When broiler litter was applied to fields, little evidence could be found for movement of hormones from the point of application to nearby streams or drainageways. This research is valuable to producers and society to better understand the risks associated with broiler litter application.



Broiler Litter on Bermudagrass / Tall Fescue Pastures

Pastures in 5 years of Coastal bermudagrass were direct-drill overseeded with Georgia-5 tall fescue beginning in the autumn of 1998. By overseeding this cool-season grass onto the existing warm-season grass, the grazing season could be extended from 140 days with bermudagrass only to 280 days with bermudagrass / tall fescue. Fertilizer treatments described earlier were modified in this second phase of the research study. Fertilizer Treatment A still received inorganic fertilizer, but with an increase in nitrogen fertilizer rate to 240 lb N/acre/year applied in February, May, and September. Fertilizer Treatment B was converted to a phosphorus-based broiler litter approach, in which a 1.5 ton/acre application of broiler litter occurred in February and two applications of inorganic nitrogen were applied in May and September (80 lb N/acre each time). Fertilizer Treatment C still received a nitrogen-based broiler litter approach, in which three separate 1.5 ton/acre applications of broiler litter were applied in February, May, and September to supply 240 lb N/acre/year.

Sequestration of soil organic carbon during the 12 years of bermudagrass only and bermudagrass / tall fescue pasture was initially rapid, but stabilized with time. The figure at right shows that soil organic carbon was greater when pastures were grazed than when they were hayed or left unharvested. These results were consistent across inorganic and broiler litter treatments.

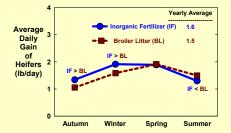


The long-term nature of this study has provided many production and environmental implications that could not have been gathered from more typical short-term experiments. The Watkinsville Research Center has a unique focus on long-term research designs to help producers balance production and environmental goals.

Broiler Litter on Tall Fescue Watersheds

A 50-acre experiment near Watkinsville was initiated in 2002 and continues today to explore how broiler litter may be interacting with endophyte infection of tall fescue pastures to affect production and environmental quality. Cattle performance and production are being measured throughout the year. Persistence of Jesup tall fescue pastures is being evaluated under three conditions: (1) with wild-type endophyte, (2) with novel endophyte (friendly fescue), and (3) endophyte free. Pastures are fertilized with inorganic fertilizer (160-40-80 lb N-P₂O₅-K₂O/acre/year) and with broiler litter in two applications (February and September) at 1.5 ton/acre/year. Nutrient analysis during the first 3 years revealed that broiler litter supplied 180 lb of N, 115 lb of P₂O₅, and 130 lb of K₂O per acre per year. This study is evaluating not only the production aspects of cattle grazing, but also the soil quality and water quality implications from these management systems. Water flumes at the bottom of each paddock will provide water quality implications from typical fertilizer and grazing management systems in the region. Each year, 150 soil samples are being collected and analyzed to find out how cattle grazing and fertilizer management are affecting nutrients in soil. Compaction, rooting depth, and soil carbon sequestration are also being measured.

Cattle weight gain has been similar on tall fescue pastures fertilized with broiler litter as fertilized with inorganic fertilizer when averaged across the entire year. However, seasonal differences have occurred. Cattle gain on pastures fertilized with broiler litter tended to be lower than pastures receiving inorganic fertilizer during autumn and winter,



but greater with broiler litter during summer (see figure at right). Seasonal differences were attributed to differences in how nutrients become available to plants, weather conditions during decomposition of broiler litter, and forage growth. Fewer nutrients are released from broiler litter during cool and dry conditions.

Water runoff has been equally low in tall fescue pastures fertilized with broiler litter as with inorganic fertilizer. As a percentage of rainfall, water runoff has averaged 10% (i.e., for every 10 inches of rainfall, 1 inch has been lost as runoff). Water runoff values are low compared with tilled cropland, in which runoff has been 15% of precipitation. Nutrient loss from tall fescue pastures has averaged less than 1 lb/acre/year for nitrogen and phosphorus. This integrated soil, water, plant, and animal research effort comparing broiler litter with inorganic fertilizer continues to produce scientifically defensible data to develop reasonable and responsible guidelines so that producers, consumers, and environmental regulators can be assured of the impacts of broiler litter application.



Dwight Fisher



Dinku Endale



Dory Franklin



Alan Franzluebbers



Michael Jenkins Microbiologist



Harry Schomberg

Broiler Litter on Cropland

A 1-acre experimental block of land with instrumentation to measure both surface runoff water and water drainage from 12 individual plots was established in the 1990s. Broiler litter application has been compared with inorganic fertilizer to determine their effects on yield of cotton and corn under two tillage practices, conventional (disk and harrow) and conservation (minimal tillage of the soil). When cotton was grown under conservation tillage from 1996 to 2000, lint yield was 42% greater when fertilized with broiler litter than when fertilized with ammonium nitrate or ammonium sulfate. This advantage was maintained even though 2 of 5 years were too dry for optimal cotton production. Broiler litter increased cotton lint yield by only 10% under conventional tillage. When corn was grown from 2001 to 2005, broiler litter increased grain yield 18% compared with inorganic fertilizer. Greater cotton lint and corn grain yield were likely due to greater soil water conservation in the conservation-tillage system and due to greater overall fertility with the diversity of nutrients contained in broiler litter. Accumulation of soil P following broiler litter application occurred only during the corn cropping phase, when a higher rate of broiler litter was applied. Further analysis of water runoff and leaching data will help us understand the environmental fate of nutrients applied with broiler litter.



Conventional tillage (upper) & no-tillage (lower)

Our results indicate that growers can conserve and use rainfall more efficiently, reduce the risk of yield-limiting droughts, and expect greater cotton and corn yields with conservation tillage and broiler litter. For corn production, alternating application of broiler litter (high P) and inorganic nitrogen fertilizer (high N) might have to be used to reduce P loading of soils. In 2007, corn cropland in Georgia doubled to 500,000 acres from the previous year, because of increasing demand related to the expanding ethanol production industry. Application of broiler litter onto an increasing cropland base could help reduce concentrated use on pastures near production facilities and help reduce environmental risks to water quality.

On-Farm Evaluation of Water Quality with Broiler Litter

Since 1999, more than a dozen farmers in Oconee and Greene Counties have been participating in a research evaluation of their management practices related to water quality in the Rose Creek and Greenbrier Creek watersheds. The WATER/FAIR project (Farmers Active in Research) has been determining the concentration of nitrogen and phosphorus in runoff from individual fields with small in-field runoff collectors (SIRCs). In addition, stream water quality has been tested before entering farms and after exiting these same farms to determine how management may be affecting water quality. Farm fields have been hayed and grazed pastures and conservation-tillage cropland. Researchers have been able to test the validity of the recently developed Georgia P Index on these farms.

Phosphorus (P) concentration in runoff from fields receiving broiler litter has not been significantly different from concentration in runoff from fields receiving inorganic fertilizer or even no fertilizer. This water quality result was contingent on the fact that soil-test phosphorus was also not greatly different among fields. With a long history of repeated broiler litter application to the same field, soil-test phosphorus could be expected to be high and runoff concentration of phosphorus would also likely be high. Some of the farms tested did have high soil-test phosphorus, but with management practices to slow water runoff, the fields were only considered at moderate risk for phosphorus loss in runoff. This on-farm evaluation of management practices has been useful to farmers to understand the effect of their management on water quality issues. It has also been useful to cooperating scientists to adjust and improve the Georgia P Index. Because of the unique research approach between farmers and scientists, greater understanding of technical and social issues occurred, as well as a unique social bond that has fostered trust and patience among participants.



Aerating Soil to Reduce Runoff of Nutrients

The buildup of nutrients at the soil surface when pastures are repeatedly supplied with broiler litter can create a significant risk of nutrient loss and contamination of surface waters when heavy rainfall occurs. In a series of experiments on small plots at the Watkinsville Research Center, various aeration techniques were conducted to understand the extent of nutrient loss in water runoff. Aeration by coring and by slitting was sometimes effective in reducing loss of nutrients from broiler litter application on higher portions of the landscape. However, there were other instances when aeration had no effect on nutrient loss in runoff. There were even events when loss of nutrients was greater from pastures fertilized with broiler litter, when aeration was conducted on low lying landscape positions with poor drainage. More experiments will be conducted to better understand how nutrients are lost in water runoff from land supplied with broiler litter. Approaches are also being investigated as to how landscapes might be designed to avoid nutrient transport from upland fields, such as grazed pastures, to streams by planting streamside buffer strips to trap nutrients prior to runoff water entering streams.